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ABSTRACT

Numeracy training was provided for employees of two Lehigh Valley (Pennsylvania) manufacturers. The curriculum was designed with a heavy emphasis on basic operation. Ten students began the course; seven completed it successfully. Unit tests evaluated each student's understanding of the material. Three students passed Qualifying Tests successfully; other students were prepared for electronics training. (Project materials, including student profiles, correspondence, and a listing of 16 references, are appended.) (YLB)

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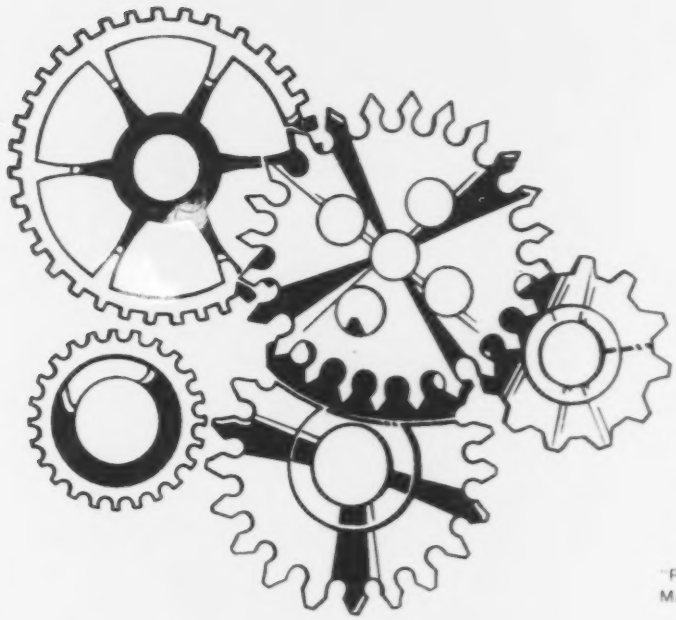
Math/Measurement for Upgrading Skills of Industrial Hourly Workers

Final Report

by
Joan McMahon



Gearing Up for the Future

Project #98-0044
Pennsylvania Department of Education

Northampton Community College

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CE 056 008

Math/Measurement Literacy for Upgrading Skills of Industrial Hourly Workers

F I N A L R E P O R T

by

Joan L. McMahon
Curriculum Developer

August 31, 1990

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Summary and Final Report

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Importance of Math Literacy in The Workplace - Past, Present, and Future

With the rise of industry's increased emphasis on the use of statistical process controls (SPC) and the increase in technology to improve productivity, reduce cycle time and foster an overall culture of total quality management, the need for improving mathematical "job-related" skills becomes increasingly critical.

Corporate America recognized the importance and need for basic skills instruction for its workers as early as the beginning of the twentieth century. In 1913, the NYC Workers Class Experiment took place.

> Its purpose was to provide an elementary education for adults. The program involved the cooperation of public schools, industry and the individual. The school system provided the teacher and the equipment, while the industrial establishment provided the room in the place of employment and the time for students to attend class without loss of wages.
>
> In September, 1913 the program was put into effect. Forty young women employed by Dudley E. Stickler Co. maker of undergarments attended class for basic skill training in reading and math.
>
> Outcome:
>
> 1) Students were enthusiastic
> 2) Work efficiency improved 20 - 70 percent
> 3) Hourly wages increased from 19.5 cents to 22.2 cents per hour.

The non-class group remained the same in efficiency and hourly wage (252-47). One year later, the General Chemical Works at Bayonne, N.J. instituted class for workers in October, 1914. The curriculum concentrated mainly in reading, understanding and speaking English and doing simple arithmetic. Several factors hindered the progress of the class. The teacher was unable to speak Polish, the attitudes of the students were impassive and unresponsive, and the selection of the material was poor. These factors could be recognized in the future as common barriers to effective literacy

education. (1)

These factors will be addressed later on in this report.

The literacy problem in our country continued to grow. By the end of World War II, nearly 750,000 persons had been rejected from the armed forces because of educational deficiencies. Those same people would now be a large part of our country's labor force. They were entering at a time then and during the 50's and 60's when major expenditures were on capital improvements, machinery and modernizing factories, and not on people - making our country's workplace literacy problems worse. Businesses started to wake up to this often camouflaged and compensated fact when technological innovation and ever increasing economic competitions from abroad demanded a better educated workforce. An example of this occurred with Digital Equipment.

> Throughout the late 70's and 1980's the Digital Equipment plants in Phoenix and Tempe, Arizona, hummed along quite nicely with the skills offered by the workers of those communities of the approximate 100 employees, many could not read or do the basic math problems. Digital Equipment required minimal technical skills at those plants. Major technological changes at these two plants required whole new sets of skills. It become evident that many of the native English-speaking employees lacked basic reading, writing and math skills. By 1986, the need for improved skills became stronger when Digital Equipment required the plants to assemble even more sophisticated equipment. (2)

1. Cook, Wanda D., Adult Literacy Education in the United States. International Reading Association, 1977

2. "Basic Literacy at Digital Equipment" Personnel Administrators, January, 1989, p. 49

Digital entered into a partnership with two local Community Colleges and as a result, basic literacy and other courses (G.E.D. prep., E.S.L. and other communication skills) are offered on site, but immediately after each shift. As a result of the training received, participants now take a more active role in decision-making in the plant.

> "It's incredible. They (workers) have a whole new self-esteem," says Frenchnan (senior production supervisor at the Phoenix plant) they are able to see how much more they are able to give to the organization and each other. These kinds of programs develop a more dedicated and loyal group of folks. These programs buy something for a company that is totally and absolutely priceless. (3)

> Digital Equipment is not alone. Chemical Bank in New York must interview forty applicants to find one who can be successfully trained as a teller. IBM Corporation discovered after installing millions of dollars worth of fancy computers in its Burlington (VT.) factories that it had to teach high school algebra to thousands of workers before they could run them. In 1987, Nynex Corp's New York Telephone Company had to test some 60,000 applicants - many of whom were minorities - to hire 3,000 people. (4)

These are just a few of the more sensational and publicized examples of the great need for training in the American workplace today. During the education conference in the Fall of 1989, at the University of Virginia, President Bush and the country's governors cited as one of the goals for the National Governor's Association Task Force on Education

3. Ibid
4. "Human Capitol - The Decline of America's Workforce, "Aaron Bernstein, Business Week, Sept., 1988.

"to achieve the level of training necessary to guarantee a competitive workforce." (5)

The future is a challenge when the present is already fraught with difficulties. Many companies are now faced with too few entry level employees and too many workers who lack basic skills. American businesses lose 20 billion every year because of illiteracy in the workforce. By the year 2000, 40 percent of the incoming workforce will be functionally illiterate.

For the first time since the eighteenth century, America is facing a major industrial revolution. In the next decade, manufacturing will decline by more than 800,000 jobs, but manufacturing productivity is expected to actually increase 2.3 percent a year.

Our ability to produce an even better product at a faster rate will be measured by the capabilities and competencies of our workers. In particular, as technological advances move forward our workforce must become more literate in basic and advanced mathematical skills. Corporate America will spend 30 Billion Dollars on training and development in 1990, a greater portion of this expenditure must be earmarked for the necessary foundation upon which our workforce can ultimately regain its competitive edge.

5. "Paying Attention to the Schools is a National Mission Now" Edward B. Fishe, New York Times, October, 1989.

The Program

A. Design and Scope

Like the rest of the working forces in America who needs to improve numeracy skills, Lehigh Valley's manufacturers are not alone in recognizing this need for training programs to upgrade the job, specific, technical skills of their employees. In order for an effective training program to be successful there needs to be a strong partnership between employers and educators. This partnership was successful because of this Grant and the cooperation and energies of everyone involved. With the assistance of the College's Center for Business and Industry, a department within the College's Community Education Division, two local companies, who were interested in upgrading the skill training of their employees who lacked basic math numeracy concepts, were identified. The area businesses who were identified were Graphics Management Associates (G.M.A.) of Bethlehem, Pennsylvania and ALPO Petfoods, Inc. of Allentown Pennsylvania. Each company had their own specific reasons for this numeracy training which will be discussed in Part B. (History and Complexion of Participating Companies)

The initial meeting with the company's representative included an Informal Questionnaire (see Addenda) to establish their objectives and goals. In addition, more specifically, a needs Assessment was conducted, (see Addenda) along with a

Numeracy Audit (see Addenda) during a tour of the individual facility. In accordance with the findings of the individual Numeracy Audit an Assessment Test (see Math Manual) was designed and implemented. When designing, administering and evaluating the results of the Assessment Test it's important to view your results from a cognitive point of view vs. a behaviorist point of view. The cognitive point of view is interested in process being used as opposed to the behaviorist, which is only interested in number of right and wrong answers.

It is important to keep in mind, based on the instruments discussed above that the curriculum developed must meet the criterion of usefulness at the individual company.

By satisfying such a condition, the knowledge can meet the needs of the learner, which, according to Dewey in the 1940's should be the starting point for any curriculum.

> Therefore, content that satisfies these needs will also motivate the learner, allowing the teacher to do a better job. (6)

Once the goals have been carefully identified and stated, the teacher defines and outlines content to achieve the goals. Instructional procedures are selected, materials are identified, and learning tasks are developed and sequenced for effective learning. Three processes should be followed:

6 Dewey, How We Think (Lexington, Mass. D.C. Heath, 1953)

1) Specifying objectives (what should be taught (numeracy audit)
2) Assessing entering behavior - level of knowledge and skill that the adult brings to the new instruction (assessment test)
3) Defining the learning unit and procedures (curriculum development) both the adult teacher and the adult learner become aware of what it is to be achieved and when it has been achieved.

There is no doubt that the curriculum selected for adults should have distinctive pertinence to their situation. If they don't initially see the importance of why learning decimals and the conversion of fractions to decimals has any significance to their working environment, the adult teacher should continually bridge the connection by reminding them of micrometers, etc. and the need of understanding basics.

The training at both companies ran concurrently, allowing for individual company attention.

B. History and Complexion of Participating Companies

1. Graphics Management Associates (G.M.A.) located in the Industrial Park in Bethlehem, Pennsylvania is a small manufacturing company of newspaper insertion machines. G.M.A., which was establish in 1976, presently employs sixty-five hourly assembly workers, whose job is to assemble

insertion machines which range in price between three hundred thousand and one million dollars. The assembly of one of these machines takes approximately two weeks. The management at G.M.A. had identified a need for basic numeracy training for its employees due to a real need for quality control and an significant increase in production. In order for an assembler to move to the next step (G.M.A. had a 5 step assembler plan set-up -- #1 being the lowest --#5 the highest. #1 least ability (with salary reflecting level) he had to pass a qualifying exam which was a test of quantitative ability. This was a strong motivater for the employee to attend the class. In essence, helping both the employee and employer. Management was also very much interested in pleasing the employee due to the fact that the UAW was looking to establish itself at the plant (at the present time there was no union). Interestingly enough, the voting took place during the training period, and the organizing attempt of the UAW to represent the employees was rejected by the employees at that time.

2. ALPO Petfoods, Inc. of Allentown, which was established in 1947, is a large manufacturer of pet foods. It employs approximately one-hundred fifty hourly maintenance and maintenance electricians. Because the management at ALPO was interested in further training which would consist of electronics and maintenance controls supplied by the College's Community Education Department an

introductory course of basic numeracy skills was in order. This training would also count towards a training step increment for anyone attending the course. (ALPO gave credit for any internal training or outside class the employee successfully completed) This increment step would be reflected in the hourly wage.

C. The Student Worker (Adult Learner)

Like the national economy, human motivation is a topic that people know is important, continuously discuss, and would like to predict. We all know motivation is important. Two people with like abilities, same exact opportunities and conditions to achieve, the motivated person will surpass the unmotivated person.

In order for adults to be motivated he must see success and have the volition and see the value to what he's doing. In order to see success, there shouldn't be any barriers. Some barriers that are common among adult learners are older adults attending a training class after not attending a class in a long time, and an adult with a poor educational background - an adult who was an unsuccessful student. Very often these adults are thought to have had learning disabilities when they were attending school. My feeling is that in many cases it was not learning disabilities, but learned disabilities. Learned disabilities may result when concepts or skills are taught incorrectly or inadequately.

They may also result when the learner lacks the developmental maturity to insure acquisition of meaningful concepts. When the adult learner starts to see success, motivation is high, and the competence builds confidence.

G.M.A.'s students worker was an average age of 30 (see Addenda - Student Profile Chart) who on the whole did not have a very successful formal schooling experience. Numeracy skills were low (witnessed by the Assessment Test) and many of them had learned disabilities. The student attended class after their eight hour shift of work, without receiving any compensation from the company.

The curriculum was designed with a heavy emphasis on basic operation. Letters were sent to many publishers (see Addenda) investigating appropriate math curriculum in the workplace. The Scott Foresman series proved to be very helpful for the students to work on a individual basis. A Student Prescription (see Addenda) was designed for each student, in order for the students to fine tune basic skills using the Scott Foresman, Essential Mathematics for Life books. The following books were used in the series according to the student's individual needs:

1. Whole Numbers
2. Decimals and Fractions
3. Percents, Graphs, and Measurements

Ten students began the course and seven successfully completed. The students came on their own to the College's Math Computer Lab for two classes. For many of them this was

the first time they had ever been close to a computer. Many of the G.M.A. students expressed an interest in attending classes at the Community College to further their education.

ALPO's student worker was an average age of 42 (see Addenda) who on the whole had a successful formal schooling experience and whose numeracy skills were high. A presentation of the course was made to each shift and strictly up to the individual as to whether he wanted to attend. There were a few older students whose gap between training presented a slight barrier.

The ALPO student attended the class after his eight hour shift, but received time and one half their normal hourly wage for attending. Sixteen students started the course, with twelve successfully completing it. This group of students did not use calculators until the Decimals Unit. (see Curriculum)

The ALPO student also travelled to the Community College for Computer Literacy Class with the emphasis placed on the Algebra Software. These students travelled 18 miles each way (on their own time) for this class.

D. The Teacher (Trainer)

The teacher in the workplace is one who should know his material extremely well. It's important that he gets involved in the instructional design and if necessary uses his sharp analytical skills to rework instruction when

necessary. The trainer should have excellent interactive skills and be capable of handling himself with different people with different needs. The teacher needs to establish a good rapport, always keeping in mind that they are not entertainers consuming all the time needed, but trainers.

Another very important ingredient necessary to be a good adult teacher is for the teacher himself to be a learner. He must possess strong motives and a positive attitude toward learning. For, it is this attitude which itself communicates most forcibly, not his words. Nothing is as transparent as is the attitude of another to learning.

I believed Joseph Epstein sums it up very well:

> What all the great teachers appear to have in common is love for their subject, an obvious satisfaction in arousing this love in their students, and an ability to convince then that what they are being taught is deadly serious.
>
> Joseph Epstein

This holds true for teachers of adults and children alike.

E. Results and Future Suggestions

How do we measure the effectiveness of a good training program? The first thing you want to keep in mind is not to pass out a form asking "Did you like it?" Because if I want

you to say that I will teach it to you in such a manner that you will love it. That doesn't mean you learned anything, but you did like it.

Unit Tests (See Math Manual) were used to evaluate the student's understanding of each unit, except for Computer Literacy. Students had to attain a 70% on each test to have fulfilled the necessary requirements. If 70% was not attained, additional work was given and when the student was ready, tested again. At G.M.A., a tutor from the Adult Literacy Department's ACT 143 Tutor Program worked on an individual basis with two of the students.

A direct measure for this program was the successful passing of Qualifying Tests for three of the G.M.A. students, and the preparedness that the ALPO students will have for Electronics Training.

An indirect measure is in changed behavior. If that has happened, you can try to relate that change to some end result variable, whether it is productivity or reduced turnover or other measures that are appropriate. Those results were discussed in addition to the curriculum development and how the program addressed the literacy needs of local workers when a presentation of the program was made to the Bethlehem Chamber of Commerce.

Certainly, in line with a basic math course one could include critical thinking/problem solving which could be quite helpful to our American worker as we enter the era of global competition!

G. Acknowledgments

Department of Adult Literacy and Community Education for their expertise and support; my family - for their selfless understanding of my countless hours spent at Lehigh University's Library - and for the Workers I had the privilege to instruct, thank you for everything I learned from you, and renewing my faith in our American Workforce.

A D D E N D A

Sample

Suggestions for Informal Discussion Questions

Name of Company G.M.A. Graphic Management Assoc., Inc.

Address 2980 Avenue B, Bethlehem, PA 18017

Company Representative Bill Fenwich Bob Pacific

Title V.P. Operations Director Personnel

Date: 12/15/89

1. Who do you have in mind to receive the training?

   Assemblers - Low level

2. Is it one sector of the company's employees?/or is it opened to everyone?

   One sector - assemblers

3. What is the goal for improvement?

4. What criteria will you use to determine who receives the training e.g. assessment test

5. What are the company's expectations of the training

   Basic facility in handling numbers

6. Is there a Union involved? no - (but, UAW trying to establish itself)

7. The training will be given on whose time (company or employee) Employee

8. Classroom availability Yes. New situation.

9. Scheduling _____

_____

_____

10. Print material that employees use in Reports, forms

_____

_____

_____

Suggestions for Informal Discussion Questions

Name of Company _____

Address _____

Company Representative _____

Title _____

Date: _____

1. Who do you have in mind to receive the training? _____

   _____

2. Is it one sector of the company's employees?/or is it opened to everyone? _____

   _____

3. What is the goal for improvement? _____

   _____

4. What criteria will you use to determine who receives the training e.g. assessment test _____

   _____

5. What are the company's expectations of the training

   _____

6. Is there a Union involved? _____

7. The training will be given on whose time (company or employee) _____

8. Classroom availability _____

9. Scheduling _____

_____

_____

10. Print material that employees use in Reports, forms

_____

_____

_____

Sample

Needs Assessment Questionnaire

1. Who is affected by the training?

Assemblers, and ultimately everyone in the Co.

2. What kind of need is it?

Critical.

3. What is the goal for improvement?

1. Basic handling of numbers in order to perform whatever calculations are necessary.

2. Passing qualifying tests.

4. What changes do you anticipate in processes and/or equipment?

No changes in the near future.

5. Do you see any capitol investments in terms of machines/tools that would require different techniques or math requirements?

Not vertically integrated.

Needs Assessment Questionnaire

1. Who is affected by the training?

_____

_____

2. What kind of need is it?

_____

_____

3. What is the goal for improvement?

_____

_____

_____

_____

4. What changes do you anticipate in processes and/or equipment?

_____

_____

5. Do you see any capitol investments in terms of machines/tools that would require different techniques or math requirements?

_____

_____

Sample

NUMERACY AUDIT

COMPANY: G.M.A.

JOB TITLE: Assembly Machine

DUTY	STEPS	TOOLS AND MATERIALS	MATH CONCEPTS	NUMERACY KNOWLEDGE NEEDED
I. Pockets Area	1. Count Parts 2. Assemble	1. Machine Parts	1. Counting	1. Whole Numbers
II. Stock Room	1. Inventory	1. Number Equipment	1. Number Sequence	1. Reading a four digit number Place Value
III. Assembly of Frames	1. Assemble according to instructions 2. Rework	1. Machine Frames	1. Addition and Subtraction of Fraction/Decimals	1. Fractions and Decimals
IV. Hopper Assembly	1. Precision set-ups	1. Machine parts	1. Measuring	1. Metric System 2. Measurement

NUMERACY AUDIT

COMPANY:

JOB TITLE:

DUTY	STEPS	TOOLS AND MATERIALS	MATH CONCEPTS	NUMERACY KNOWLEDGE NEEDED

Profile of Students ALPO PETFOODS

Name/Title		D.O.B.	Last Grade Attended	High School Graduate Yes/No	Any Further Training School
T. H.	Electrician	7/7/50	12th	Yes	Yes
L. N.	Grounds Maintenance	7/25/43	8th	No	No
J. B.	Grounds Maintenance	6/25/35		Yes	BA DEG
H. B.	Electrician	3/23/37	10th	GED	Yes
S. S.	Electrician	10/30/38		Yes	
B. S.	Boiler Operator	7/5/49	12th	Yes	
B. M.	Electrician	4/18/51	12th	Yes	Yes
B. Y.	Electrician	12/27/45	12th	Yes	
R. Y.	Mechanic	7/3/56	12th	Yes	Yes Vo-Tech
J. Y.	Electrician	6/12/47	12th	Yes	Yes Allent. C.C.
G. A.	Mechanic II	1/26/58	12th	Yes	Yes C.C. Vo-Tech
R. P.	Electrician	8/8/50	12th	Yes	Yes Vo-Tech
R. M.	Electrician	11/27/58	11th	Yes	A.A.S.
K. K.	Mechanic	11/17/36	10th	Yes	Yes Vo-Tech
A. F.	Mechanic	6/13/42	11th	Yes	GED

Profile of Students Graphics Management Associates

Name/Title		D.O.B.	Last Grade Attended	High School Graduate Yes/No
F. L.	Assembly Mech.	5/6/45	12th	Yes
K. S.	Supervision	8/14/51	12th	Yes
J. F.	----	03/05/61	1 Yr. College	No
D. H.	Group Leader	5/6/64	12th	No
T. B.	Assembly Mech.	3/4/62	11th	GED
T. D.	Assembly Mech.	6/17/60	10th	No
P. F.	Assembly Mech.	4/3/65	10th	GED
R. B.	Assembly Mech.	11/10/63	12th	Yes
L. M.	Assembly Mech.	2/22/65	10th	GED
A. D.	Assembly Mech.	---	GED	GED College 1 1/2 Yr.

Programmed Learning
706 West Praire Street
Vicksburg, MI 49097

Dear Representative:

I am presently developing a curriculum for Math/Measurement Literacy in the Workplace for the Pennsylvania State Education Department. This curriculum will be used with approximately forty adult students who are in need of improving their basic skills.

I am very much interested in previewing "Programmed Math" - Decimals, Percents, and Fractions - PL 1004 - PL 1007, PL 1008 - PL 1011, PL 1012 - PL 1018.

In addition, if you presently have any adult math skills workbook(s) or text(s) currently in development, I would be eager and willing to preview. Your material (if used) will be listed in a book of bibliography sources.

Thank you,

Joan McMahon

Name _____

Areas of Concentration:

1. _____ 5. _____
2. _____ 6. _____
3. _____ 7. _____
4. _____ 8. _____

Prescription: Date Completed

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____

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